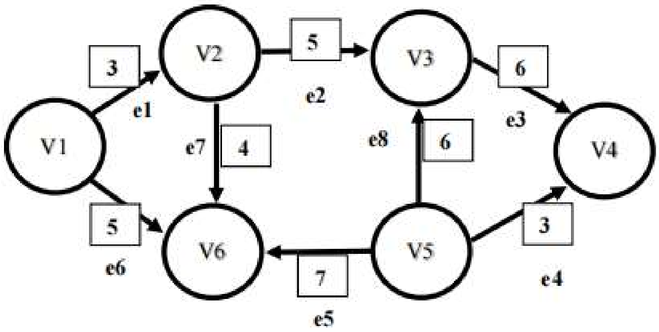
الجمهـــوريـــــة الجزائـريـــــة الديمـــقـــراطيـــــة الشعبيـــــة
People`s Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research National School of Cyber Security		وزارة التعـليـم العـــالـي والـبحـــث العـــلـمـي المدرســـة الوطنيـــة العليـــا في الأمـن السيبراني
Foundation Training Department		قســم التكويـن القــاعدي
LEVEL : 1st Year Basic Training	**Tutorial Sheet No. 4**	**MODULE : Graph Theory**

Exercise 1:

Let the following graph G be:



1. The vector representing the cycle e1 e2 e8 e5 e6 is:

(+1 +1 -1 0 -1 +1 0 0) ☐ (+1 +1 0 0 +1 -1 0 0) ☐ (+1 +1 +1 +1 0 0 0 0) ☐

2. The vector representing the cycle e2 e8 e5 e7 is:

(0 +1 0 0 +1 0 -1 -1) ☐ (0 -1 00 -1 0 +1 +1) ☐ (0 +1 -1 -1 +1 0 0 0) ☐

3. The co-cycle associated with the vertex set (V2 V3 V5 V6) is:

=(e1,e6) U (e3,e4) ☐ =(e3, e6) U (e1, e4) ☐ (e2, e7) U (e5, e8) ☐

4. The representative vector of the co-cycle Ω(V2V3V5V6) is:

(-1. 0 +1 +1 0 -1 0 0) ☐ (+1 0 -1 +1 0 -1 0 0) ☐ (0 -1 0 0 +1 0 -1 +1) ☐

5. The co-cycle Ω(V2 V3 V5 V6) is elementary:

True ☐ False ☐

6. The co-cycle Ω(V1 V2 V6) is elementary:

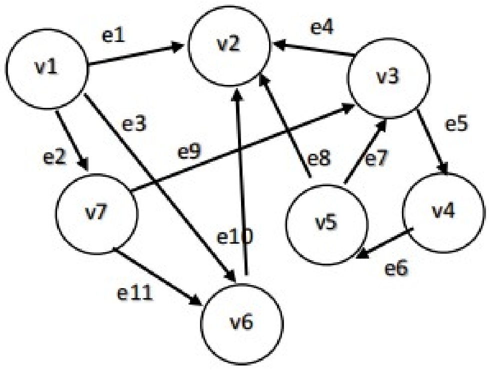
True ☐ False ☐

7. By applying the FORD-FULKERSON algorithm, the maximum flow in the graph G:

8 ☐ **9** ☐ **None of the previous answers** ☐

Exercise ***2:***

Let the following graph G be:



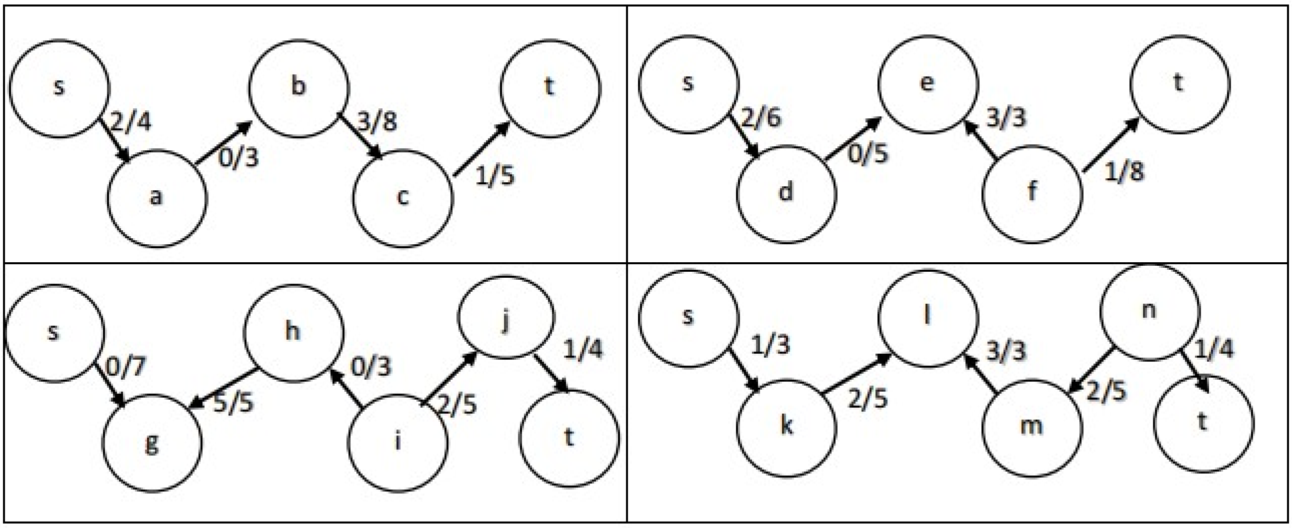
1. Give the vector notation of the following cycles: **(e1, e10, e3), (e4, e5, e6, e8), (e1, e10, e11, e2)**.
2. Calculate the cyclomatic number associated with the graph G.
3. Determine the co-cycle associated with each of the following sets of vertices:

   A={v1, v7}, B={v1,v7, v2}, C={v1, v2, v6, v7}

4. Which of these co-cycles are elementary?

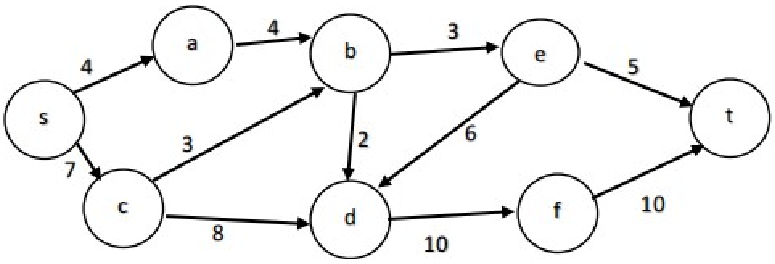
Exercise3*:*

Improve flow in the following subsequent chains where possible. Edges are weighted by the ratio: current flow/edge capacity.



Exercise4*:*

A water company has a set of interconnected pipes of various diameters and wants to transport a maximum quantity of water through the pipe network. How much water can actually be transported?



Exercise5*:*

A machine **T** is connected to a server **S** by a network having nodes **A**, **B**, **C** and **D**. The connection capacities between the nodes are given in the table below (in Mbit/s).

	A	B	C	D	T
S	2	6	1		
A		3		7	
B				3	5
C		2		6	
D	3				4

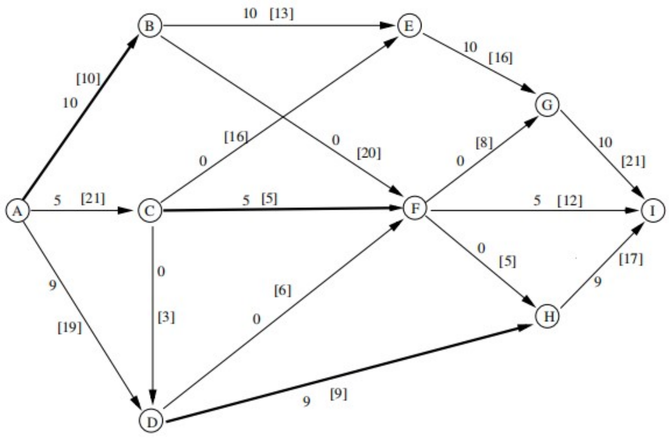
The user of machine T downloads a very large file from server S.

1. Model this network by a graph.

2. Using the Ford-Fulkerson algorithm (maximum flow), find the routing that maximizes the throughput in this network.

Exercise6*:*

A road network between two cities **A** and **I** is represented schematically by the diagram below. The capacity of each edge is proportional to the number of vehicles that can flow in one hour in the corresponding section. The flow on each edge is proportional to the number of vehicles that actually pass in one hour in the corresponding section, according to the measurements made by the equipment services.



1. What is the current value of the flow through the network?
2. Using the Ford-Fulkerson algorithm, determine the maximum flow that could flow between **A** and **I**, in the event of an increase in traffic (from the current situation).
3. Indicate a minimum cut. What is the capacity of this cut?